A search for close companions in Sco OB2

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Abstract. Using adaptive optics we study the binary population in the nearby OB association Scorpius OB2. We present the first results of our near-infrared adaptive optics survey among 199 (mainly) A- and B-type stars in Sco OB2. In total 151 components other than the target stars are found, out of which 77 are probably background stars. Our findings are compared with data collected from literature. Out of the remaining 74 candidate physical companions 42 are new, demonstrating that many stars A/B stars have faint, close companions.

1 The primordial binary population in Sco OB2

The primordial binary population (PBP) is defined as the population of binaries as established just after the gas has been removed from the forming system, i.e. when the stars can no longer accrete gas from their surroundings [3]. Characterizing the PBP is important for our understanding of the process of star formation, the formation and evolution of OB associations, the origin of the field star population and OB runaway stars, and the production and evolution of binary systems. OB associations are ideal sites for the study of the PBP. Since OB associations are young ($5-50$ Myr) and low density (≈ 0.1 M$_\odot$ pc^{-3}) stellar systems, the effects of stellar and dynamical evolution are modest. OB associations are practically cleared of gas and the full stellar population (from OB stars to brown dwarfs) is present. Sco OB2 (Figure 1) is the closest young OB association, its proximity facilitating the detection of close and faint companions. The membership and stellar content has been established with *Hipparcos* [6], and many binary surveys have been performed in the past.

2 Adaptive optics observations

We performed a near-infrared adaptive optics (AO) survey among 199 (mainly) A- and B-type stars. Our sample is a subset of the *Hipparcos* membership list of Sco OB2 [6]. The AO observations bridge the observational gap between the

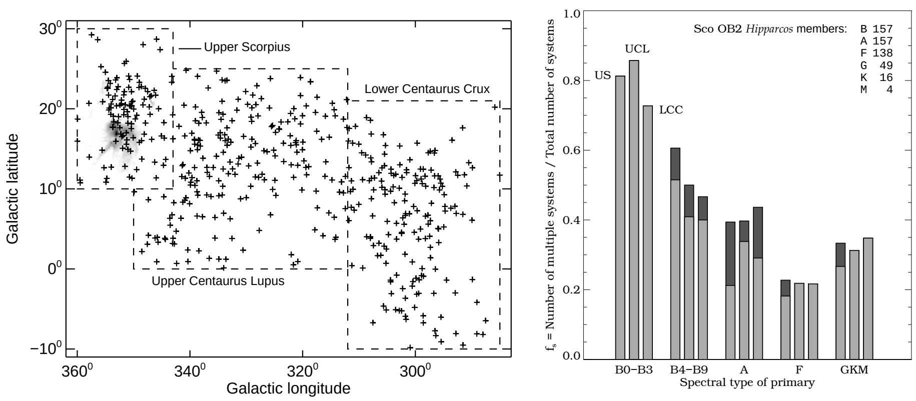

Fig. 1. *Left:* The three subgroups of Sco OB2. The ρ Oph star forming region is visible in the upper-left corner in grey scale (IRAS 100 μm). *Right:* The fraction of stellar systems which is multiple versus the spectral type of the primary, for the three subgroups of Sco OB2. Only confirmed Hipparcos member primaries are considered here. The light and dark grey parts of the bars correspond to literature data and the new data presented in this article, respectively.

wide visual and close spectroscopic binaries. In the near-infrared the luminosity contrast between the primary star and its (often later-type) companion(s) is lower, which facilitates the detection of faint and close companions. The observations were performed with the ADONIS/SHARPII+ system. This AO system was mounted on the ESO 3.6m telescope on La Silla. The camera field of view is 12.8 × 12.8 arcsec. Each star is observed at four different pointings in order to maximize the available field of view. The angular separation between the target stars and the other components in the field ranges between 0.2 and 15 arcsec. All target stars are observed in the K_S band, for some also J and H band observations are obtained. We applied standard data reduction techniques in combination with image selection, retaining only the highest Strehl ratio images. We find a total of 151 stellar components in the fields around the 199 target stars. For each detected component the projected distance, position angle, and relative magnitude are measured.

The status of an observed component (companion star or background star) can be determined using the colour-magnitude diagram: companion stars are expected to lie on the isochrone, while background stars are not [5]. For most of our target stars only the K_S magnitude is available to determine whether a component is a companion star or a background star. We have used a simple brightness criterion to separate background and foreground stars. We consider all stars fainter than $K_S = 12$ to be background stars, and the stars brighter than $K_S = 12$ companion stars (the magnitude of an M5V star at the distance of of Sco OB2 is $K_S = 12$). Using this method we find 74 candidate companion stars and 77 probable background stars.

Subgroup	D (pc)	Age (Myr)	N_s	N_b	N_t	N_m	f_s	f_c	CSF
Upper Scorpius	145	5	63	46	7	3	0.47	0.67	1.61
Upper Centaurus Lupus	140	13	131	68	17	4	0.40	0.61	1.52
Lower Centaurus Crux	118	10	112	54	13	0	0.37	0.57	1.45
Scorpius OB2			303	171	37	7	0.41	0.61	1.52

Table 1. Multiplicity among *Hipparcos* members of Sco OB2. The columns show the subgroup names, their distances [6], the ages [2], the number of known single stars, binary stars, triple systems and $N > 3$ systems. The last three columns show the binary statistics: the fraction of multiple systems $f_s = (N_b + N_t \ldots) / (N_s + N_b + N_t + \ldots)$, the fraction of stars in multiple systems $f_c = (2N_b + 3N_t \ldots) / (N_s + 2N_b + 3N_t + \ldots)$ and the companion star fraction $CSF = (2N_b + 3N_t \ldots) / (N_s + N_b + N_t + \ldots)$, which measures the average number of companion stars per primary star.

3 Binary statistics and observational biases

We combine our observations with literature data on binary in Sco OB2. This dataset includes visual, astrometric, spectroscopic, and eclipsing binaries. A careful comparison shows that 42 out of the 74 candidate companion stars that we found are new: 14 in US, 14 in UCL and 14 in LCC (Table 1). It was pointed out by [1] that the observed number of multiple systems with A- and late B-type primaries is relatively low due to observational biases. Part of this selection effect is now removed with our new AO observations (Figure 1).

4 Future work

The ultimate goal of our study is to determine the PBP. We will achieve this by combining the binary data of Sco OB2 with detailed numerical models. These models are N-body simulations including state of the art stellar and binary evolution [4]. Simulated observations will be produced to characterize in detail the selection effects for the different binary surveys. These simulations will also be used to investigate the impact of dynamical and evolutionary effects that may have altered the binary population over the lifetime of Sco OB2. Combined with the knowledge about the selection effects the PBP can then be reconstructed. The results will provide the characteristics of the binary population as a function of environment just after the star formation process has finished. This is an important constraint on theories of star (cluster) formation.

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